High Resolution Multispectral and Hyperspectral Data Fusion for Advanced Geospatial Information Products

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LONG-TERM GOALS

This project seeks to develop the technology to fuse high spatial resolution MultiSpectral Imagery (MSI) with lower spatial resolution, but higher spectral resolution, HyperSpectral Imagery (HSI) to provided enhanced target detection and battlespace characterization. It seeks to push beyond traditional PAN sharpening techniques to develop applications that will increase the accuracy and fidelity of the sharpened spectral imagery.

OBJECTIVES

1) Co-register high resolution MSI data with HSI data collected during the Fall of 2004.

2) Correct the MSI data for illumination and atmospheric interference to derive a broadband remote sensing reflectance, Rrs, measurement from the MSI data.

3) Develop methodologies to fuse the HSI data with the higher spatial resolution MSI data, using the spectral characterization of the MSI Rrs data stream.

APPROACH

The fusion of remote sensing data from different sensors has a long history of success in the terrestrial environment (Pohl and Genderen, 1998). Its application in ocean remote sensing has accelerated in recent years with the use of multiple resolution, multiple frequency optical and microwave imaging. The optical imagers include both active (e.g. LIDAR) and passive (e.g. HyperSpectral Imagers, HSI). Microwave imagers are typically Synthetic Aperture Radar (SAR). While the field has been generally confined to airborne and space-based platforms, imagery data fusion may also include some combination of data from these platforms with data from in-water systems such as multibeam and side-

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14. ABSTRACT
This project seeks to develop the technology to fuse high spatial resolution MultiSpectral Imagery (MSI) with lower spatial resolution, but higher spectral resolution, HyperSpectral Imagery (HSI) to provided enhanced target detection and battlespace characterization. It seeks to push beyond traditional PAN sharpening techniques to develop applications that will increase the accuracy and fidelity of the sharpened spectral imagery.

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scan sonar imagery. In short, data fusion is the process by which two or more streams of data of different temporal and spatial resolution are combined to produce synthesized products which are unattainable from a discrete image.

The advantages of data fusion are fairly clear. In the temporal domain, data fusion allows for the more complete imaging of an area intermittently covered by clouds. It may also provide better analysis of movement or time-dependent change in targets and/or environmental conditions. In the electromagnetic frequency domain, targets which are visible in one image type may be less than visible in another, and vice versa. SAR imagery may illuminate target elevations or directional wave spectra, whereas optical imagery may identify targets by shape and color. Combining the targeting and identification of these different data types provides target recognition and environmental characterization with high confidence and lower false alarm rates than may be found from single source imagery. In the spatial domain, objects that are identifiable on the basis of size and shape in panchromatic (PAN) imagery are often unidentifiable by their geometric dimensions in lower resolution imagery multispectral or hyperspectral imagery. The converse is that the spectral imagery provides the ability to identify targets or characterize the environment based on unique spectral signatures, which is unavailable in the panchromatic imagery, but may not be able to resolve the shape or dimensions of small targets.

This project seeks to co-locate simultaneously collected MSI/HSI data streams to develop enhance imagery sharpening capabilities for use in target detection and environmental characterization. It seeks to build upon PAN sharpening techniques by using the full spectral information provided by MSI data stream. We hypothesize that the best way to attempt this image fusion is at the level of remote sensing reflectance, so the MSI data must be corrected for illumination and atmospheric interference. The spectral information from the co-registered MSI/HSI Rrs data will then be fused to provide more accurately sharpened HSI data for spectral target algorithms.

WORK COMPLETED

This project began in April of 2005, and started with data previously collected by FERI. FERI, in collaboration with the California State University System, under the NOAA-funded California Center for Integrative Coastal Observation, Research and Education (CICORE) Program (http://www.feriweb.org/projects/ci-core/) recently (Fall 2004) collected over 5,000 square kilometers of 0.3 meter MSI and 3 meter HSI data over a wide variety of coastal environments along the California coast (http://www.feriweb.org/projects/ci-core/arcims/). The survey sites include Humbolt Bay, San Francisco Bay, Monterey Bay, the Big Sur coast, San Luis Bay, Santa Barbara, Newport, and San Diego Harbor. The MSI instrumentation was provided under a cooperative agreement with the Applanix Systems Integration Group (ASIG) subsidiary of the Trimble Corporation. This MSI system (Digital Sensor System; http://www.applanix.com/products/dss_index.php) was provided as part of the Applanix Position and Orientation System (POS AV; http://www.applanix.com/products/posav_index.php), which was being evaluated as a replacement for the current POS system on the NRL PHILLS 2 airborne hyperspectral imager.

The raw DSS imagery (MSI imagery) and POS data was provided to FERI by ASIG after the flights. The processing and geo-positioning of the MSI data was completed by FERI under this ONR project. This geo-positioning system is of much greater accuracy than the previous POS system on the PHILLS 2. The processing of this POS data stream required additional training, which was provided by ASIG. In addition, the DSS is a frame camera imagery, which is very different from the line scanning imager,

which is at the heart of the PHILLS 2. The processing of the MSI data stream itself required additional training in the photogrammetry and ortho-rectification. The training was completed, as well as the processing of the raw POS data and DSS imagery to ortho-rectified (Figure 1). These data are to be used with the co-registered HSI data from the Morro Bay region (Figure 2).

Figure 1. FERI MSI of selected region in Morro Bay, CA collected November 11, 2004. This area has been chosen as a focus site for the development of the MSI/HSI fusion algorithms. Note the enhanced spatial resolution when compared to the HSI imagery in Figure 2.

RESULTS

The MSI/HSI data has been co-registered in anticipation of the next step in the development of the spectral fusion over the next 6 months. One issue that has been found during the training of FERI personnel by ASIG, which may be cause for difficulties, is that the radiometric and spectral calibrations of the DSS are not what have been purported by the manufacturer. The calibration issues need to be resolved prior to the development of the Rrs fusion approach, for it will be very difficult to correct for illumination and atmospheric effects without accurate calibration. This recalibration of the MSI sensor by FERI personnel is scheduled to occur this fall (funded by Trimble), so these data should be available later this year to complete the initial development of the Rrs fusion approach.

IMPACTS/APPLICATIONS

The abilities to detect targets and characterize the environment in the Very Shallow Water (VSW) and beach zone are critical to MIW, MCM, and NSW operations. The image fusion techniques here will provide enhanced abilities to detect and characterize target in access denied areas using both geomorphology (shape) and spectral (color) signatures. In addition, the successful development of these techniques will feed back into the development of new imaging systems for space and aircraft platforms, including Unmanned Aircraft Systems (UAS).

Figure 2. FERI HSI of selected region in Morro Bay, CA collected November 11, 2004. This area has been chosen as a focus site for the development of the MSI/HSI fusion algorithms. Note the reduced spatial resolution when compared to the MSI imagery in Figure 1.

RELATED PROJECTS

This project works closely with those of PIs Bissett and Kohler, including N000140110201, N000140310626, and N000140410297

REFERENCES

Pohl, C. and Genderen, J.L.V., 1998. Multisensor image fusion in remote sensing: concepts, methods and applications. International Journal of Remote Sensing, 19(5): 823-854.